SOIL SURVEY OF THE BELLEFOURCHE AREA, SOUTH DAKOTA.

By A. T. STRAHORN and C. W. MANN.

DESCRIPTION OF THE AREA.

The Bellefourche area is located in the western part of South Dakota, within a few miles of the Wyoming State line. Nearly all of the area lies within Butte County, and the remainder, a few square

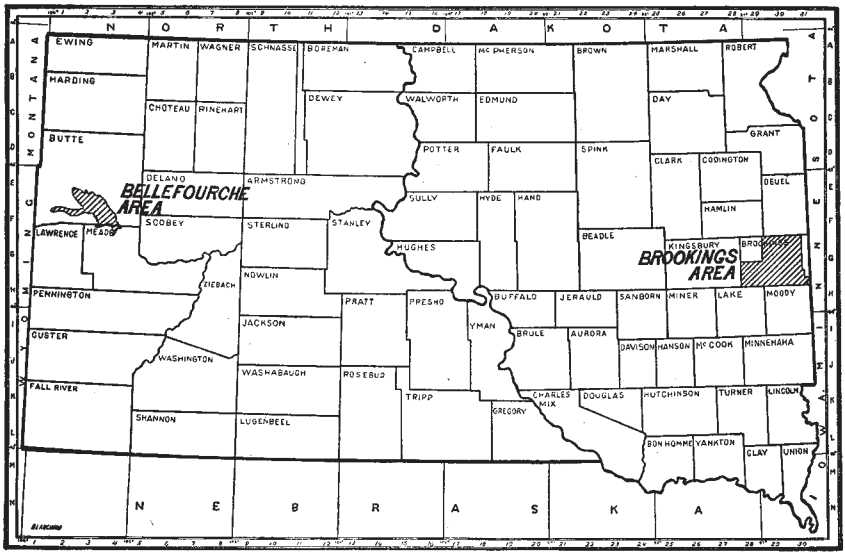

FIG. 30.—Sketch map showing location of the Bellefourche area, South Dakota.

miles of the southeastern part, falls within the boundaries of Meade County. The area comprises Tps. 7 to 10 N. and Rs. 2 to 7 E., Black Hills base and meridian, and includes about 121,000 acres of irrigable land. The shape of the area is very irregular, the boundaries being governed by the course of the Red Water irrigation canal, and by the course of the canals of the Government irrigation project. The greatest length of the area from east to west is about 30 miles, and the greatest width from north to south about 14 miles.

The area consists of the winding valley of the Bellefourche River, the narrow valleys of tributary streams, the high river terraces, and the rolling foothills forming the local watersheds. The largest stream

is the Bellefourche River, which, entering the area at the southwest corner, flows in an easterly direction with a very winding course and leaves the area at the extreme southeast corner. Its principal tributaries on the south side, from west to east, are Hay Creek, Redwater River, and Stinkingwater, Whitewood, Cottonwood, and Ninemile creeks. On the north side of the river, in the same order, are Crow, Owl, Horse, Dry, and Willow creeks. Of these streams, Redwater River and Whitewood Creek carry water during the entire year, as their sources lie well back in the hilly or mountainous regions south and southwest of the area. The other streams, draining a much smaller country, become dry soon after the cessation of the early summer rains. The drainage basin of the streams in this area is almost destitute of timber, and as a result the run-off of storm waters is rapid, and the streams, which rise rapidly following the heavy rains in the spring and early summer, soon fall to their normal level.

In general the formation of the land is such as to give a ready and thorough surface drainage. The exceptions to this are a considerable body of very level land in the western part of the area known as Indian and Owl creek flats, and a depression south of the proposed Government town site. Following the heavy spring rains the former region is almost impassable, owing to standing water and the sticky nature of the soil. The depression south of the proposed town site collects the surface storm waters from the adjacent country, forming a pond of some 200 to 300 acres in extent. Water usually stands in this depression throughout the summer.

This part of the country prior to the coming of the whites was inhabited by roving bands of several tribes of Indians, the Sioux tribe being the most numerous. Just when this section of the State was first traversed by white men is uncertain, but probably early in the eighteenth century. Before 1700 the Hudson Bay Company had an outpost on the Missouri River near the present site of Mandan, and a few years later the American Trading Company had an outpost near the present site of Pierre, on the Missouri. It is not unlikely that some of the trappers in their quest for furs ascended some of the streams in this part of the State. The fur business declined and for many years little was known of the Black Hills and surrounding country. Shortly after the civil war hunters and prospectors began to drift into the country and were soon followed by cattlemen, who found conditions ideal for the feeding of vast herds of range cattle. The coming of the whites was strenuously opposed by the Indians, particularly the Sioux, who caused considerable trouble until subdued soon after the Custer massacre and placed upon a reservation in the southern part of the State. Stories of gold in the Black Hills caused

a rapid increase in the population of that district, from which point settlers soon moved into outlying districts. Since then there has been a steady increase in the population of this section of the State.

There are four towns in the area, Bellefourche, Snoma, and Vale, all situated along the Bellefourche River, and Minnesela on Redwater River. The last of these was at one time the county seat of Butte County, but soon after the building of the railroad the courthouse was removed to Bellefourche. Snoma and Vale are small settlements in the more thickly settled part of the valley east of Bellefourche. Bellefourche is the principal town, and being situated on the Chicago and Northwestern Railroad, is the point of supplies for a vast stretch of country to the north and northwest. Prior to the construction of the railroad, in 1888, the obtaining of supplies was a costly and tedious operation for the settlers. All supplies had to be hauled into the area by wagons from distant points, Cheyenne, Wyo., Sidney, Nebr., Pierre, S. Dak., and Bismarck, N. Dak., all being prominent outfitting and supply points for this section of the State.

Railroad transportation is now afforded by a line of the Chicago and Northwestern Railroad, which gives a ready outlet to the Black Hills, Omaha, Lincoln, and Sioux City. A short line, known as the Wyoming and Missouri River Railroad, runs from Bellefourche to Aladdin, Wyo., which is a stock-shipping and coal-mining point. The eastern and southern portions of the area connect with the railroad by wagon roads to Whitewood and Sturgis, points on the Chicago and Northwestern line. At the present time practically all of the farm products are consumed within the area, or shipped into the Black Hills, while the sheep and cattle shipped out of the area go to some of the large packing-house concerns in Omaha, Chicago, and Sioux City. There is a good demand for all kinds of farm produce in the mining towns and surrounding country to the southwest.

CLIMATE.

The records of the precipitation and temperature for this area are very incomplete, the only record being that taken by the Reclamation Service, partly covering the last three years.

The normal annual rainfall for the area is estimated at about 17 inches, although it varies widely from year to year, ranging from about 12 to 20 inches. The larger part of the rainfall usually occurs in the spring and early summer, from March to the last of June. During this season very heavy rains are not unusual, as much as 3½ inches falling within twenty-four hours. The fall of snow is rarely heavy and seldom covers the ground for any length of time. Electrical storms are rare.

The mean temperatures at reservoir site, as recorded by the United States Reclamation Service, are as follows:

Mean monthly temperature at reservoir site.

Month.	1906.	1907.	Month.	1906.	1907.
January		12.0	July	71.4	68.2
February		27.9	August	68.5	
March		31.0	September	62.7	
April		39.6	October	48.0	
May	49.6	47.8	November	33.5	
June	62.0	62.5	December	27.0	

Some data regarding the precipitation at a few towns south of the Bellefourche area, in the edge of the Black Hills, are available. The figures given are the mean of average annual precipitation, based on records covering a period of over twenty years. They give an idea of the rainfall near the sources of many of the streams entering the area. The mean annual rainfall is as follows: At Spearfish, 21.8 inches; Rapid City, 16.34 inches; Fort Meade, 19.41 inches; Silver City, 22.05 inches. The total yearly rainfall at Spearfish varies between 12 and 29.4 inches.

The annual range of temperature in this area is wide, being about 130°. Winter temperatures of —30° F. have been recorded, while in July and August temperatures above 100° F. are not uncommon. The cold of winter is frequently modified by a warm wind from the southwest, locally known as the "chinook." On account of the low humidity neither of the extremes of temperature causes any serious results.

The average date of the last killing frost in the spring is about May 5, and of the first in fall is about September 15. As a rule very little damage is done to the crops by frost either in this area or nearer the hills.

Wind is a prominent feature of the climate of this area, as there is hardly a day without a good breeze, and in the spring and autumn months winds of high velocity may blow for several days at a time. The number of cloudy days is small.

In the following table are given the maximum and minimum temperatures, the mean monthly and annual temperature and precipitation, and the total precipitation, by months, for the wettest and driest years, and the depth of snow, as taken from the records of the United States Weather Bureau station at Spearfish, which lies a short distance south of the area surveyed.

Temperature and precipitation for Spearfish, S. Dak.

Month.	Temperature.			Precipitation.			
	Mean.	Absolute maximum.	Absolute minimum.	Mean.	Total amount for the driest year.	Total amount for the wettest year.	Snow, average depth.
	°F.	°F.	°F.	*Inches.*	*Inches.*	*Inches.*	*Inches.*
January	25	65	−30	1.0	0.3	0.5	9.2
February	21	67	−30	1.0	0.4	0.8	10.6
March	30	80	−20	2.2	1.1	4.0	20.9
April	46	88	1	3.0	1.1	5.6	14.6
May	55	93	24	3.0	3.6	3.1	1.2
June	64	105	33	4.1	1.4	2.3	0.0
July	71	105	43	2.0	1.9	3.0	0.0
August	70	104	40	1.6	0.1	3.7	0.0
September	60	97	26	1.1	0.6	3.9	0.8
October	49	90	17	1.3	0.8	0.4	2.3
November	35	79	−11	0.6	0.2	0.6	5.8
December	31	71	−17	0.9	0.4	1.5	8.9
Year	46	105	−30	21.8	11.9	29.4	74.3

AGRICULTURE.

The earlier settlers in this area cared little or nothing for farming, their interests being centered in the cattle industry, the almost limitless range, with a plentiful supply of grass and water, making the area unusually well adapted to this pursuit. Owing to the requirements of the range, the dwellings were usually miles apart, and the farming areas were confined to small fields close to the ranch houses. Very few ranches could boast of a garden, it being considered easier to buy vegetables than to take the trouble to grow them. Native hay and oats or wheat, and occasionally corn for feeding the farm stock, were about the only crops grown.

When viewed in the light of good farming practice, the methods pursued by the earlier settlers in the production of these crops left much to be desired, and it is to be regretted that these methods are still in use by many of the farmers. The usual practice was to break the sod to a depth of 2 or 3 inches the first year in order to kill the grass and weeds, and to plant corn on the fresh sod with a hand planter. In the second year the method pursued in the cultivation of the land varied with different farmers. Many sowed wheat or oats directly upon the corn stubble without stirring the soil, save as this was done by the seeder. Others plowed the land the second year and planted the grain either with or without harrowing. In years of high rainfall good yields would be obtained, even with this inadequate preparation of the soil, but in seasons of deficient rainfall the yields were hardly sufficient to pay for the seed. While the above may be

taken as a fair average of the cultural practices of the earlier settlers, and even of the farm practices to the present time in the dry-farm districts, yet in many instances even less care was taken in the preparation of the soil, and cases are known where small grain following corn has been planted three or four years in succession without any plowing or cultivation of the soil. Such methods are becoming less common, and among the more recent settlers better cultural methods are noticeable and a somewhat wider variety of crops is produced. Alfalfa has been introduced, and the yields vary from 1½ to 2½ tons per acre, depending upon the rainfall. In addition to oats and wheat, rye, barley, and millet have been grown to a limited extent, fair yields being obtained without irrigation. Potatoes in favorable years give abundant yields. Brome grass is one of the most recently introduced crops, and although the acreage at the present time is very small, it gives promise of becoming a valuable addition to the crops grown without irrigation. In the last few years vegetable gardens near the ranch houses have become more common, and these in some cases, besides supplying the home needs, are proving profitable to the owners from the sale of the surplus in the local markets.

Up to the present time little or no attention has been paid to the selection of soils for particular crops. It is commonly held that the Pierre clay, or "gumbo," as it is locally known, produces better crops of hay and alfalfa than the lighter sandy soils. Little or no attention has been paid to the rotation of crops in this area, the question as to what to sow being decided by the immediate need and desire of the farmer.

The methods of dry farming might be greatly improved and the increased yields would in average years be more than sufficient to justify the extra time and money invested in the thorough cultivation of the soil. When the moisture in the soil is sufficient, the land should be deeply plowed in the fall, since this will materially aid in storing the moisture of the winter rains for the use of the summer crops. In the spring the ground should be plowed as early as the weather conditions will permit and then thoroughly harrowed. By these means a large part of the moisture in the soil will be retained for the growing crops. In growing cultivated crops, such as corn, the surface soil, subsequent to the seeding, should be thoroughly cultivated, so as to produce a mulch of loose soil to aid in holding the moisture. Not only should this loose condition of the surface soil be obtained in the spring, but cultivation should be continued throughout the growing season, particularly after the summer rains. In the planting of alfalfa and small grains, the sowing of a smaller amount of seed per acre will in general be found to give increased yields, since the moisture in the soil of dry-farmed districts is rarely sufficient for a thick stand of these crops.

In the irrigated district of this area, under the Redwater Canal, more attention is given to the preparation of the soil, although in some cases deeper plowing might be practiced with good results. While the soil is, as a rule, better prepared than in the dry-farm districts, in many cases the subsequent cultivation is neglected. It is not uncommon to see fields in which the corn is almost smothered by weeds.

In seasons of average rainfall very little trouble is had in curing hay, and this fact has made some of the farmers in the valley, particularly in the dry-farm section, careless in handling this crop. Fields were noticed where the hay had been allowed to remain on the ground in windrows from ten days to two weeks. This greatly reduces the value of the hay for feeding purposes, even though no rain occurs, and in rainy seasons it is badly damaged if not altogether ruined by this practice. The small grain is shocked in the field without capping, after which it is either thrashed directly from the shock or hauled and put into stacks until it is convenient for the owner to thrash.

This area, like most other farming sections of the West, suffers at all times from a lack of farm labor, and in the haying and thrashing seasons the need of help becomes pressing. Farm hands receive from $25 to $30 a month and board, when employed throughout the year. In haying and harvesting seasons help commands from $40 to $60 a month and board. Less than 20 per cent of the farms in this area are worked by tenants, the owners farming the larger part of the land.

The value of lands within the area varies widely and the general trend of values is upward. Up to within the last three or four years land outside of the irrigated district could be bought for $7 to $10 an acre, but since this area has been made into an irrigation project by the Reclamation Service the prices asked for these same lands have risen, and now range from $12 to $20 an acre. Very little of the land under the Red Water Irrigation Canal is on the market.

South of this area there is a well-cultivated and irrigated district along Spearfish Creek, a branch of Redwater River, and from the conditions which exist there some idea may be gained of what may be expected when this area is placed under irrigation. The soil in general along that stream is somewhat lighter than the average soil in this area, and is very much like the Vale loam, excepting that it is of a decidedly red color and contains some gravel. The conditions of rainfall and temperature are also very similar, though this valley is not so subject to heavy winds as the Bellefourche country. Alfalfa and the small grains yield abundantly, and corn in most years gives good returns. The growing of apples and small fruits has developed into a paying industry and there is a demand for more of these prod-

ucts than has been produced up to the present time. The growing of peaches is not considered profitable, since the trees can not withstand the winter climate. Plums do well, and pears, although just being tried, are apparently adapted to the region. Small fruits yield abundantly, but in unusually severe winters are damaged by the cold, and it has become the practice of the careful farmers to lay the vines down during the winter and cover them with earth. The Wealthy apple has proved to be well adapted to the valley and is gradually forcing out other varieties.

Some fruit is grown in the area surveyed, but in very small, widely scattered orchards, and not enough has been done in this line to show the capabilities of the soil for these crops. All of the orchards observed in this area have been on the lighter textured soils, and the trees seem to be making good growths and giving fair yields. The larger proportion of this area has a very heavy soil, and its adaptability to the fruit industry is as yet an unsolved problem. If the fruit industry is to be developed and made profitable in this area, it is probable that the trees and vines will need to be protected from the heavy winds which blow during the spring months, by windbrakes of trees planted around the orchard, just as is done in some parts of California.

SOILS.

The rocks from which the soils of this area have been derived are largely the Pierre shale, and, to a lesser extent, several geological formations in and adjacent to the Black Hills. The basal formation of this area is the Dakota Sandstone of the Cretaceous age, and this is the lowest formation within the area which is of any importance. This sandstone was deposited early in the Cretaceous age, following which there was a period of clay deposition, the material accumulating to a depth of several hundred feet and subsequently indurating to form the Pierre shale. Three soils are made up entirely of material resulting from the decomposition of this shale. These soils—the Pierre clay, Orman clay, and Pierre clay loam—differ from one another in texture, topography, and mode of formation, being, respectively, residual, lacustrine, and alluvial in origin. The other soils in the area are not derived from the Pierre shale, but are underlain at varying depths by the shale or by-products resulting from its decomposition. The upper portion of these soils is made up almost entirely of material eroded from a variety of rocks in the Black Hills and transported and laid down by streams issuing from that region. The products of the decomposition of the shale have had a minor influence in a few cases on these lighter soils, where the two classes of material have been intermingled. With the exception of the Vale gravelly

sandy loam, which is colluvial in formation, the lighter soils are all alluvial.

The residual soil occurs over nearly all of the eastern part of the survey, north of the Bellefourche River and east of Horse Creek, and in scattered areas throughout the balance of the area surveyed. The lacustrine soil occurs along the western edge of the area and the alluvial throughout the rest of the area.

The following table gives the name and extent of each of the soil types in the area:

Areas of different soils.

Soil.	Acres.	Per cent.	Soil.	Acres.	Per cent.
Pierre clay	41,088	33.9	Vale loam	3,520	2.9
Pierre clay loam	24,192	19.9	Vale gravelly sandy loam	2,304	1.9
Vale fine sandy loam	23,936	19.7			
Orman clay	14,912	12.3	Total	121,344	
Meadow	11,392	9.4			

MEADOW.

The texture of the Meadow type of soil varies from a clay to a gravelly loam, the texture being due to the soils from which the streams erode the soil material. Where this type occurs along streams flowing into the Bellefourche River from the north the texture of the soil to a depth of 6 feet is a heavy impervious clay. Those areas occurring along the Bellefourche River and along the water courses flowing into it from the south are generally sandy loams, varying from coarse to fine, underlain by a bed of waterworn gravel and sand. In a few places this gravel forms nearly the entire type, only a thin layer of soil being on the surface to serve as a foothold for vegetation.

The color of the heavier phase of this type is a dark brown or black at the surface, due to organic matter in the soil, while the subsoil is a light brown, or, rarely, a yellowish brown. In the lighter phase of the soil the color is a light brown or, where very sandy and gravelly, yellowish.

Meadow occurs as small irregular bodies along nearly all the water courses in the area. Along the Bellefourche River the surface of the soil is fairly uniform, occasional small depressions marking the courses of a part of a former stream. Along the smaller streams the surface is so uniform that it is hard to note any exceptions.

The drainage of the lighter portions of this type is excellent, owing to the open texture of the soil and the gravel in the subsoil. In the heavier portions of the type the drainage is poor, owing to the impervious subsoil, and swampy conditions exist throughout the year in the lower-lying areas.

The Meadow owes its origin to the periodical overflows of the streams in the spring and the deposition of soil material carried in suspension by them. The streams through the northern part of the area receive their waters from a region made up of a clay soil, and the material eroded and carried by them is very fine, and when deposited forms a heavy clay soil, which is the heavier phase of this type. The streams through the southern portion carry coarser material in suspension, and this forms the sandier phase of this soil. A few small areas of this type have been formed since irrigation has been practiced on the lands south of the Bellefourche River, and these are due to seepage of irrigation waters from higher levels to lower lands of deficient drainage.

With few exceptions, the bodies of this type lying along the streams in the northern and western parts of the area contain alkali, a large proportion of the Meadow area having an average alkali content of from 0.40 to 0.60 per cent for the upper 6 feet of soil. A smaller proportion contains alkali averaging from 0.20 to 0.40 per cent, while a little of the type—the lighter phase—is entirely free of alkali. Owing to the periodical overflows and the consequent saturation of the upper portion of the soil there is seldom any injurious amount of alkali in the first 24 inches. Below this the quantity of alkali usually increases with the depth.

Along the Bellefourche River the Meadow supports a luxuriant growth of cottonwood, willow, ash, and elm, and a good growth of grasses and weeds. Along the smaller streams the timber is less abundant, but there is found a heavy growth of native grasses, which make good hay and excellent pasturage.

Up to the present time only a few small, widely scattered areas of the Meadow are cultivated, and the yields obtained depend largely on the extent of the spring floods and the amount of the early summer rains. With the increase in population and the demand for farming land this type of soil should become of importance, the lighter phase being well adapted to the growing of vegetables, while with proper handling the heavier phase should be a strong, lasting soil.

VALE GRAVELLY SANDY LOAM.

The Vale gravelly sandy loam consists of a light-brown coarse sandy loam, or a fine sandy loam carrying varying quantities of water-worn gravel, the proportion usually increasing with the depth. The gravel ranges in size from fine gravel to pieces 4 to 5 inches in diameter. In exposures along river terraces or in excavations it is found that the sandy surface material forming the soil is usually underlain at 3 to 10 feet by finer and heavier material, generally a clay loam.

This soil occurs principally along old river terraces, marking the course of former streams, along the higher banks of the present course

of the Bellefourche River, and as small, low elevations throughout the southern part of the area. The surface is generally uneven and along the river terraces frequently precipitous.

The Vale gravelly sandy loam is formed by the material brought down by the streams from the northern part of the Black Hills and adjacent country.

In the past this type of soil has been of little or no agricultural importance, it being used only as pasture in connection with adjoining lands. A larger part of its area will never be of value for agriculture on account of the steep surface, and the remainder is not suitable for dry farming, as the soil dries out rapidly in the summer. Under irrigation the more level areas should prove well adapted to such fruits as thrive on gravelly soils and as can withstand the winter climate of this region.

The following table gives the results of the mechanical analysis of a fine-earth sample of the soil:

Mechanical analysis of Vale gravelly sandy loam.

Number.	Description.	Fine gravel.	Coarse sand.	Medium sand.	Fine sand.	Very fine sand.	Silt.	Clay.
		Per cent.	*Per cent.*	*Per cent.*	*Per cent.*	*Per cent.*	*Per cent.*	*Per cent.*
17754	Soil	3.0	10.9	9.6	27.8	13.8	24.4	9.5

VALE FINE SANDY LOAM.

The Vale fine sandy loam may consist of 6 feet of fine sandy loam, but is frequently underlain at 24 inches by a clay loam extending to a depth of 6 feet or more. The subsoil frequently contains thin layers of a lighter material, usually a sandy loam. The texture of the surface soil varies considerably with the topography, some of the higher areas approaching a sand, owing to the removal of the finer material by surface washing, while lower-lying areas approximate a heavy fine sandy loam or a silt loam. The clay loam subsoil is very compact, and below 6 feet it usually grades into a clay which extends to 12 or 16 feet, where it is underlain either by a heavy clay, locally known as "blue clay," or by a bed of waterworn gravel. The usual color of the soil is a reddish brown, which weathers to a light brown on the surface. The subsoil varies in color from a dark to a light reddish brown.

The Vale fine sandy loam is found in the southern part of the area, the largest bodies occurring on the south side of the Bellefourche River northeast of Bellefourche and east of Vale. A narrow area, becoming wider at its eastern end, extends along the north side of the river from the diversion works of the Government irrigation system to the mouth of Owl Creek. Small, scattered, irregular areas

occupy the lower lands on the north side of the river from the mouth of Owl Creek to the eastern limit of the survey, and a few irregular areas occur west of Vale between the hills and the Bellefourche River and extend along the line of the canal. In the western part of the survey there are no very prominent topographic features connected with this type, the rather uniform slope to the river being broken only by a few shallow draws and by a somewhat ill-defined old river terrace.

Eastward to Vale the larger portion of this type lies along the lower levels and but little above the overflow land along the river. Southwest of Miller Butte an area of this soil occurring on a high bench has a very level surface, excepting a depression near the western edge, which usually contains water throughout the year. East of Vale this soil occurs in two or three benches, with more or less well-defined escarpments between them.

The Vale fine sandy loam is an alluvial soil and owes its origin to material carried by streams draining the Black Hills country and deposited above the heavier subsoil, which is partly made up of material derived from Pierre shale.

This soil is practically free from alkali. Northwest of Bellefourche, below the Redwater Canal, there is a small area where traces of alkali occur, though not of sufficient extent to map. East of Vale, near the Bellefourche River, there is an area where widely-scattered spots contain traces of alkali. In a few localities where the subsoil is heaviest small amounts of alkali occur in the fifth and sixth foot, but not in sufficient quantities to be indicated on the map.

Dry farming and farming under irrigation are both practiced on the Vale fine sandy loam. In the dry-farming sections this soil produces good crops in years of average rainfall, alfalfa yielding on the average about 2 tons per acre, oats 25 bushels, and corn 15 bushels. In years of deficient rainfall dry-farm crops on this soil will hardly return the seed planted in the spring. All of this type south of the Bellefourche River and to a point about 2 miles east of Snoma is under irrigation, water being obtained from the Redwater Canal. Under irrigation this soil has proved well adapted to the crops grown in this section, alfalfa and oats giving heavy yields. Alfalfa produces from 5 to 7 tons per acre with three cuttings, oats 60 to 70 bushels, and wheat 25 to 35 bushels. Corn gives good returns, but in seasons of early frost it sometimes fails to mature. The soil is loose and easily handled, and with irrigation should prove adapted to a wider range of crops. A few small orchards are found upon this type, and the trees seem to be making a good growth. With proper protection from winds it is likely that apples, cherries, and a variety of small fruits would succeed on this soil.

The following table gives the results of mechanical analyses of the soil and subsoil of this type:

Mechanical analyses of Vale fine sandy loam.

Number.	Description.	Fine gravel.	Coarse sand.	Medium sand.	Fine sand.	Very fine sand.	Silt.	Clay.
		Per cent.	*Per cent.*	*Per cent.*	*Per cent.*	*Per cent.*	*Per cent.*	*Per cent.*
17755	Soil	0.1	0.7	0.3	8.4	24.5	55.9	10.7
17756	Subsoil	.1	.5	.8	14.9	33.5	37.3	12.6

The following samples contained more than one-half of 1 per cent of calcium carbonate ($CaCO_3$): No. 17755, 3.90 per cent; No. 17756, 4 per cent.

VALE LOAM.

The Vale loam is variable in texture and occurs in this area in two phases—a loam phase and a sandy loam phase—the latter not occupying a sufficient area to be indicated upon the soil map.

The heavier phase, to a depth of from 12 to 30 inches, consists of a loam. This is underlain by a clay loam, rarely a clay, to a depth of 6 feet. In a few small areas the surface 2 inches is made up of fine sandy loam. Below 6 feet the soil is heavier, and at 12 to 16 feet it rests either on a heavy clay or on a bed of waterworn gravel. The soil contains varying quantities of gravel, particularly in the vicinity of old stream terraces. The color of the soil is brownish, with usually a reddish tinge, while the subsoil is darker and frequently contains yellowish-brown streaks.

The light or sandy loam phase consists of 6 feet of heavy, sticky, sandy loam, containing quantities of fine gravel. Like the heavier phase, it rests either on clay or gravel at 12 to 16 feet. The color of this phase is a light reddish brown.

The Vale loam occurs in the southern part of the area surveyed as irregular-shaped widely separated bodies, the largest of which lies mainly between Whitewood and Cottonwood creeks, west of Vale. A part of the type occurs between Bellefourche and Snoma below the Redwater Canal, and two small areas near the southeast corner of the survey.

The surface in the western part of the survey slopes toward the Bellefourche River, and the drainage is excellent. Near the line of the Redwater Canal the slope is quite pronounced, but becomes more gradual toward the river and adjoining soils. Shallow washes or gullies traverse the areas at intervals, making the surface somewhat rolling. In the area west of Vale the surface is for the most part level, and adjacent to the river it is cut by a narrow strip of Vale gravelly sandy loam, which marks the course of a prominent river terrace. It is in this area that the heavy subsoil comes near the surface, and on

account of the rather level surface and compact subsoil the drainage is deficient. A small arm of this area extending toward Butte Hill has a good slope, and here the drainage is better.

The Vale loam is both a lacustrine and alluvial soil, parts of the type having been laid down in bodies of water once covering this area, and other parts having been formed by the deposition of material carried in suspension by former streams. The latter areas have been somewhat modified since their deposition by the addition of small quantities of material washed down from the higher slopes of the foothills, making the surface soil somewhat more heavy than the outlying portions. At present this type does not contain sufficient quantities of alkali to be indicated upon the map, though in some areas small quantities of alkali are found in the fifth and sixth foot, which may be brought to the surface if faulty methods of irrigation and cultivation are practiced.

The western areas of this soil are under irrigation, the water being obtained from the Redwater Canal. Alfalfa and small grains, principally oats and wheat, do well, and the yields approximate those obtained on the Vale fine sandy loam. The other areas of the type are not irrigated, and very little of it is cultivated.

The larger part of the soils in the Redwater and Spearfish valleys is made up of a loam similar to this type, differing, however, in color and in being underlain at from 5 to 10 feet by beds of gravel. In these valleys soil of this character has proved well adapted to apples, plums, cherries, and small fruits.

The following table gives the results of mechanical analyses of the soil and subsoil of this type:

Mechanical analyses of Vale loam.

Number.	Description.	Fine gravel.	Coarse sand.	Medium sand.	Fine sand.	Very fine sand.	Silt.	Clay.
		Per cent.	*Per cent.*	*Per cent.*	*Per cent.*	*Per cent.*	*Per cent.*	*Per cent.*
17758	Soil	0.4	3.3	4.2	15.6	20.1	31.9	23.9
17759	Subsoil	.2	4.3	4.8	38.8	7.9	28.2	15.1

PIERRE CLAY LOAM.

The Pierre clay loam consists typically of from 12 to 30 inches of rather heavy clay loam, underlain to 6 feet by a very heavy tenacious clay. In a few cases the clay loam extends to a depth of 6 feet. The soil is light brown in color, which weathers upon the surface to a whitish or ashy-gray. The subsoil is almost invariably of a brown color, although yellow streaks are sometimes found below 3 feet. In the subsoil of the higher lying areas there often occur small, roughly cubical fragments of a grayish or light-brown stone, derived from the weathering of the clay concretions occurring in the Pierre shale. Below 6 feet the soil continues a heavy clay to a depth of 10 to 40 feet

or more, where it is underlain by a heavy blue clay. Occasionally a thin bed of gravel overlies the clay. Bodies of this soil lying south of the Bellefourche River have at times come under the influence of streams draining the Black Hills, and sometimes contain small quantities of waterworn gravel.

Next to the Pierre clay, this type of soil is the most extensive in the area, and occurs as isolated bodies or as bodies covering a considerable section of country. The most extensive development is found along Horse Creek. A fair-sized area occurs in the vicinity of Vale, and small areas are found along Ninemile Creek and in the southwestern part of the survey.

The Pierre clay loam, on account of its wide distribution, has a variety of topographic features, ranging from low, poorly drained areas to the slopes of the foothills. Southwest of Vale a part of the soil has rather poor drainage, owing principally to the construction of a small irrigation reservoir on Cottonwood Creek. The land near the reservoir has a gentle slope and during the spring rains it becomes wet from overflow waters. The larger part of the type, however, has excellent surface drainage. There is practically no movement of water downward, as the subsoil in unirrigated areas was very dry, notwithstanding the unusually heavy rainfall during the spring of this year (1907). In the areas under the canal the continued application of irrigation water for a series of years has had but little effect on the subsoil, which is only moderately moist.

The upper part of the soil, and in some cases the entire soil, is of alluvial origin, while a larger part of the subsoil is residual, resulting from the decomposition of Pierre shale.

South of the Bellefourche River the Pierre clay loam contains but little alkali, the areas being small, with an average alkali content of 0.20 to 0.40 per cent for 6 feet of soil. In the southeastern part of the survey, along Ninemile Creek, traces of alkali occur near the stream and tributary draws, but in areas too small to be shown on the map. North of the Bellefourche River the larger part of the soil contains alkali in sufficient quantities to be mapped. The upper 18 or 24 inches of soil is generally free from harmful quantities. In irrigating this soil care should be taken to prevent the rise of the alkali to the surface and the injury of the land. Although even where alkali accumulates it will be feasible to reclaim the land, the process is slow and costly in soils of this heavy texture, and the better way is to guard against the evil. Some of the lower lying areas will undoubtedly suffer from a rise of alkali soon after irrigation is commenced, but by proper attention much of the type can be farmed for many years with no serious results. On the areas along the canal no injurious effects have been noticed from the use of irrigation water, as the soil

in these portions possesses good surface drainage and the excess of water flows off to lower levels.

The Pierre clay loam supports a good growth of grass, and is used to a limited extent as a range for stock. The areas near the streams are used for wild hay. A considerable portion is farmed without irrigation, the principal crops being alfalfa and oats, with some wheat and corn. The yields obtained vary widely, being dependent upon the annual rainfall, but the following estimates are approximately correct: Alfalfa 2 tons, oats 30 bushels, wheat 15 to 20 bushels, and corn 12 bushels per acre. There seems to be no reason why, with more careful cultural methods, larger yields may not be secured.

On account of the heavy, sticky nature of this soil, it requires careful handling in order to obtain a good seed bed. If stirred when too wet the soil forms into hard clods, which are almost impossible to break down by cultivation, while if plowed when too dry the soil breaks into a fine dust, which will blow badly and render irrigation of the fields difficult.

The following table gives the average results of the mechanical analyses of the soil and the results of a single determination of the subsoil constituents of this type:

Mechanical analyses of Pierre clay loam.

Number.	Description.	Fine gravel.	Coarse sand.	Medium sand.	Fine sand.	Very fine sand.	Silt.	Clay.
		Per cent.	*Per cent.*	*Per cent.*	*Per cent.*	*Per cent.*	*Per cent.*	*Per cent.*
17747, 17749	Soil	0.1	0.5	1.9	11.1	21.5	44.4	20.2
17748	Subsoil	.1	.1	.4	1.5	16.0	48.1	33.6

The following samples contained more than one-half of 1 per cent of calcium carbonate ($CaCO_3$): No. 17747, 3.45 per cent; No. 17748, 5.95 per cent.

PIERRE CLAY.

The Pierre clay consists of 6 feet of an extremely heavy tenacious clay, which, particularly in the eastern portion of the area, contains considerable quantities of small light-brown or gray cubical fragments of broken-down clay concretions. Throughout the area frequent small knobs or elevations only a few inches high mark the location of these weathered concretions, which have not been scattered through the soil. Sometimes the soil does not extend to a depth of 6 feet, but such occurrences are rare. Where this occurs the soil is harder and more compact and passes gradually into beds of weathered shale. The surface of the Pierre clay has a whitish or ashy-gray color, while below the surface the color varies from light to dark brown. If the lower soil is exposed it slowly loses the brown color and becomes a light gray.

The Pierre clay is the most extensive of the soils of the Bellefourche survey, occupying about one-third of the total area. It covers nearly all the area north of the Bellefourche River and east of Horse Creek. Other smaller bodies of the type lie along Owl Creek, north of Indian Creek, and near Snoma. None of this type has been found on the lands under the irrigation project south of the river.

The surface is generally irregular, on account of numerous water courses and draws, with prominent hills and ridges between the streams. In the eastern part of the area the erosions are numerous and deep, making the surface very irregular. Excepting a few depressions which hold water seeping from surrounding land, the drainage is excellent.

The Pierre clay is a fine example of a residual soil, having been formed by the slow weathering of the immense beds of Pierre shale underlying the entire area. Erosion subsequent to formation of this soil has cut down the original surface, resulting in the present topography, varied by hills, valleys, and stream courses.

The larger part of the area of this soil contains alkali in sufficient quantities to be indicated upon the map, and over much of the affected area the content is high enough to cause some concern as to the results when irrigation waters shall be applied. The heavier accumulations of alkali in this type occur north and south of the proposed Government town site, in both cases the alkali content ranging from 0.60 to 1 per cent for the upper 6 feet of soil. Aside from these areas of high concentration, the area of alkali soil of this type is about equally divided between the grades of 0.20 to 0.40 per cent, and 0.40 to 0.60 per cent.

A portion of this soil, on account of the good surface slope, may never be troubled with dangerous accumulations of alkali, but over the larger part extreme care will be required in irrigation if serious damage from alkali is to be prevented. Owing to the extremely heavy nature of the soil, the movement of the alkali will be slower than in the lighter soils, but it will be none the less certain. The reclamation of the soil would be slow and expensive, and the conditions leading to the need of reclamation should be avoided.

The Pierre clay produces a fair growth of native grasses, and is largely used for grazing. On the lower lying areas the growth of native grasses is better, and small patches are cut for hay. The acreage which is farmed is relatively very small, and the greater part of the type is still unpatented land. Outside of the irrigated sections the farming is confined to small areas near the farmhouses. Very often the farming consists of a little patch of small grain on land that is being homesteaded, in order to secure the title to the land. Near Snoma, where this soil is irrigated, it gives promise of good crop

returns. The yields obtained from this irrigated section are similar to those obtained on the Pierre clay loam.

The following table gives the average results of mechanical analyses of the soil of this type:

Mechanical analyses of Pierre clay.

Number.	Description.	Fine gravel.	Coarse sand.	Medium sand.	Fine sand.	Very fine sand.	Silt.	Clay.
		Per cent.	*Per cent.*	*Per cent.*	*Per cent.*	*Per cent.*	*Per cent.*	*Per cent.*
17750, 17751	Soil	0.2	1.1	1.4	5.5	13.0	43.2	35.0

The following samples contained more than one-half of 1 per cent of calcium carbonate ($CaCO_3$): No. 17750, 2.32 per cent; No. 17751, 0.59 per cent.

ORMAN CLAY.

The Orman clay consists of 6 feet of extremely heavy, tenacious clay. In one or two cases, near the streams, the clay was found to be underlain at 4 feet by a heavy sandy loam or by a sandy loam with gravel extending to a depth of 9 feet or more. Rarely this type contains fragments of shale concretions like those found in the Pierre clay, although along the line of contact with the latter soil a few of these are occasionally found.

The Orman clay occurs in a large body in the northwestern part of the area, extending over what is known as Indian and Owl creek flats, and in two smaller areas in the eastern part of the survey near the Bellefourche River.

The topography of the Orman clay is in striking contrast to the topography of the rest of the area surveyed, since with the exception of a small gullied area west of the northern part of Indian Creek the surface is extremely flat. The two small areas of this type in the eastern part of the survey are also very level, the one adjacent to the Bellefourche River terminating in a high bluff at the water's edge. Across the western portion of this type Owl and Indian creeks have cut a flat-bottom draw, often a quarter of a mile wide, with the bottom of the stream from 10 to 20 feet below the surface of the plain.

On account of the very level surface the drainage is not good, and during the spring rains the surface is under water. Some of this water finds its way into one or the other of the two creeks, but a considerable portion remains on the surface until removed by evaporation.

The Orman clay is of lacustrine formation, the soil having been laid down in a large body of water which at one time covered this part of the area. The material of which the soil is composed is the finer products derived from the decomposition of Pierre shale.

Alkali is distributed generally throughout this soil and in such quantities that with irrigation there will be great danger of the larger portion of the land being rendered worthless for agriculture. At present there is very little alkali in the first 18 inches of soil, but below that depth the percentage is high. The entire area in the western part contains on an average from 0.40 to 0.60 per cent of alkali to a depth of 6 feet.

Owing to the very level surface and the lack of adequate drainage, in order to prevent the accumulation of alkali more care will have to be taken in irrigating and cultivating this soil than with any other in the area. The alkali content of the subsoil is high, and under conditions which exist it is hard to see how damage is to be entirely prevented. By care in the use of water and by thorough cultivation a considerable time will elapse before any injurious effects will be noted. The early construction of drainage ditches would do much to aid in keeping down the alkali.

At the present time hardly any land of this type of soil is under cultivation, but aside from the alkali problem it is probably well adapted to the crops grown in this section.

The following table gives the average results of the mechanical analyses of the soil of this type:.

Mechanical analyses of Orman clay.

Number.	Description.	Fine gravel.	Coarse sand.	Medium sand.	Fine sand.	Very fine sand.	Silt.	Clay.
		Per cent.	*Per cent.*	*Per cent.*	*Per cent.*	*Per cent.*	*Per cent.*	*Per cent.*
17752, 17753	Soil	0.0	0.0	0.2	4.2	11.0	47.7	36.1

The following samples contained more than one-half of 1 per cent of calcium carbonate ($CaCO_3$): No. 17752, 1.36 per cent; No. 17753, 1.50 per cent.

IRRIGATION.

Up to the present time the only successful irrigation works in this area have been the Redwater Canal and a private canal taking water from a reservoir near Vale. From time to time since the settlement of the valley, attempts have been made by the settlers to take water from the Bellefourche River or some of its tributaries, but owing to the large volume of water sometimes carried by these streams, the irrigation works have been repeatedly destroyed, until the settlers have become disheartened and have ceased their efforts to irrigate the lands. Some living along the larger creeks have endeavored to construct earthen dams across the streams, so that in times of high water the streams would flow across adjacent hay lands and thus insure a larger yield of native hay. Owing principally to faulty

construction, these dams have soon given way under the pressure of the water, and these attempts have also been abandoned. Small reservoirs have been constructed in various parts of the area along the smaller streams, but these are largely used for watering stock rather than for irrigation.

The main sources of the water for irrigation are Bellefourche and Redwater rivers. The Bellefourche rises in Wyoming west and northwest of the Black Hills, and drains a rolling, treeless country with a heavy compact soil. As a result the discharge of this river is very irregular and given to sudden rises following the spring storms. In seasons of unusual rainfall, the river overflows large areas of adjoining land, doing more or less damage to bridges, farm buildings, and live stock. Below is given the discharge of this stream as determined by the United States Reclamation Service.

Estimated monthly discharge of Bellefourche River.

[Drainage area, 4,265 square miles.]

Month.	Total discharge.			Depth of run-off.		
	1903.	1904.	1905.	1903.	1904.	1905.
	Acre-feet.	*Acre-feet.*	*Acre-feet.*	*Inches.*	*Inches.*	*Inches.*
March	----------	[a] 46,601	[b] 17,030	----------	0.20	0.075
April	----------	30,957	17,140	----------	.14	.076
May	----------	32,684	46,850	----------	.14	.206
June	10,955	158,432	35,880	0.05	.70	.157
July	12,343	20,770	64,200	.05	.09	.282
August	56,016	7,740	48,510	.25	.03	.213
September	54,363	14,717	15,170	.24	.06	.067
October	10,870	[c] 10,241	----------	.05	.04	----------

[a] March 10–31. [b] March 5–31. [c] October 1–15.

The Redwater River, which rises southwest of Bellefourche, in Wyoming, drains the northern and northwestern parts of the Black Hills and adjacent country and empties into the Bellefourche River just east of the town of Bellefourche. This stream takes its name from the color of the water during times of high water, when it is a bright red, caused by material eroded from several geological formations having this color. The flow of this stream is not as great as that of the Bellefourche River, and although there is considerable variation in the discharge between high and low water stages, yet the rises are never so sudden as in the larger stream. The Redwater River receives its waters from a district which is partly forested, and the run-off is less rapid following heavy rains. The discharge of this river at its junction with the Bellefourche, for 1904, as determined by the United States Reclamation Service, is given on the following page.

Discharge of the Redwater River.

Month.	Discharge.	Depth of run-off.	Month.	Discharge.	Depth of run-off.
	Acre-feet.	*Inches.*		*Acre-feet.*	*Inches.*
January			July	10,880	0.201
February			August	5,688	.105
March 10-31	9,295	0.172	September	10,710	.198
April	13,210	.244	October	13,030	.241
May	8,854	.164	November	11,600	.214
June	65,220	1.20	December	13,400	.248

The combined flows of these two streams will furnish water for the irrigation system now in course of construction by the United States Reclamation Service.

Chemical analyses of water taken from the Bellefourche and Redwater rivers show respectively only 148 and 106 parts total solids per 100,000, from which it will be seen that it is well suited for use in irrigation, as the quantity of dissolved material carried is not sufficient to be harmful to crops.

In 1887 a merchant at Vale purchased water rights on Cottonwood and Whitewood creeks, and a right of way for a canal from these streams to a point near Vale. A dam was built across Whitewood Creek, a canal constructed, and water delivered to a few acres sown to alfalfa in 1890. The reservoir filled up with silt and sand in a few years, and was abandoned. Another dam was constructed on Cottonwood Creek and has been in use since 1895. The capacity of this reservoir is about 2,000,000 cubic feet. It irrigates a small field of alfalfa just south of Vale. In seasons of deficient rainfall little water is caught in the reservoir and little or no land is irrigated. The yield of hay varies from 2 to 5 tons per acre, depending upon the quantity of water stored.

The construction of the Redwater Canal was begun in 1878 and was gradually extended until in 1889 it reached Stinkingwater Creek, 5 miles east of Snoma. Water was delivered to the end of the line for only a short time, and the end of the canal has been at a creek about 1½ miles east of Snoma for many years. The water for this canal is taken from the Redwater River at the junction of this stream and Flat Bottom Creek, about 2 miles south of the boundary of this survey. A portion of the canal southeast of Bellefourche passes along a steep gravelly hillside where there is some loss by seepage, but over the remainder of its course it traverses a rather heavy soil which holds the water well. The canal was originally constructed to carry about 100 second-feet, but it has not been kept in repair and the flow at the present time is considerably less. The lower end of the canal carries hardly sufficient water to supply the farmers in that locality

the quantity necessary for their crops. The Redwater Canal irrigates about 5,000 acres of land, and there are about 3,000 acres more which might be irrigated from this ditch.

The United States Reclamation Service is now engaged in the construction of an irrigation system which will, when completed, furnish water for the irrigation of about 95,000 acres, and will extend to all of the land within the area surveyed, excepting the higher elevations and the land now under the Redwater Canal. The construction of this system includes the building of a dam and weir to divert the waters of the river, a supply canal leading to the reservoir from the diversion works, an earthen dam at the reservoir site, and a system of canals and laterals for the distribution of the water.

The dam at the reservoir is one of the largest of its kind, and when completed will, at the high-water mark, retain about 246,016 acre-feet, with a water surface of 9,000 acres. Two main canals will carry the water to the laterals. The North Side Canal, forming the northern boundary of the area, will have a capacity of 582 second-feet at the head. The South Side Canal will have a capacity of about 240 second-feet at the dam. The first canal will supply water for about 66,875 acres and the South Side Canal will cover about 28,200 acres. About half of the land is Government or school land, and the rest is in private ownership.

It will be some time before all the lands under the Government project will be supplied with water, but by an order of the Secretary of the Interior, dated June 21, 1907, about 12,000 acres will be supplied with water in the spring of 1908. All of this land is in private ownership, and lies along the north side of the Bellefourche River from the diversion works eastward to the point where the South Side Canal crosses the river.

The Redwater Canal can, as it now stands, supply the land below it with water, but unless enlarged and cleaned out it will not be able to cover any more country. There is a body of land lying east of Snoma to Stinkingwater Creek admirably located for irrigation, which might be covered by this canal if the latter were put in better shape and extended.

The surveys made by engineers of the Reclamation Service show that there is a considerable body of land east of Willow Creek, beyond the present area, which may be irrigated by an extension of the canals of the present system when the demand for these lands shall arise.

Since alfalfa and small grain occupy the largest acreage, flooding the fields is the usual method of irrigation. A considerable quantity of water is lost by this method, as few of the fields are carefully graded, and water frequently runs from the lower edge of the field before the crop has been given the necessary moisture. By this method certain parts of the field receive an excess of water, while

others do not receive enough. On account of the surface slope of the land near the canal, flooding will probably continue to be the usual method of applying the water, but on the outlying fields basin irrigation might be practiced, with a more economical use of the water and the certainty that all of the crop will be evenly irrigated. In the case of open-culture crops, as corn and potatoes, the furrow method of irrigation is used.

The number of applications of water varies with the crop and with the individual farmer. Alfalfa is irrigated after each cutting, and also in the spring if the rainfall is slight; but many of the farmers apply water to the alfalfa between the regular irrigations which follow the cuttings. The larger number give the small grains three irrigations, but from the experience of a few in the valley it is evident that two thorough applications of water are sufficient to mature the grain and insure good yields in any but the driest years.

Under the Redwater Canal the water is sold to the farmers at $1.50 for a miner's inch, which is commonly taken to be sufficient for an acre of land. Those living at the lower end of the canal are charged $1.50 an acre, and use as much water as comes to them. In years of unusually low flow in the Redwater River these farmers sometimes do not receive the necessary water for their crops, while in years when the water is abundant they have more than they can use. Many who irrigate 100 acres or more find that they can make an inch irrigate more than 1 acre, and only take about 80 to 85 inches for 100 acres.

Under the Government system it is proposed to allow about 2 acre-feet of water for the land. The cost of this water will be a certain amount per acre. The cost of the irrigation system will be assessed against all irrigated lands within the project, and this is to be paid to the Government by the farmers in ten annual installments. In addition to this yearly cost per acre, there will be a small charge for the maintenance of the system. On that part of the project to be thrown open for irrigation in 1908 the annual charge for water has been fixed at $3.40 an acre. Three dollars of this amount is to be a payment on the construction and the remainder for maintenance.

ALKALI.

With the exception of the Vale series of soils, alkali is generally present in the soils of the Bellefourche area north of the river. South of the river alkali is found only in small quantities and in restricted areas. The larger part of the higher slopes and ridges is practically free from alkali; a few cases were noted where there were small quantities of alkali below 3 or 4 feet, but not enough to map. The immediate bottoms along streams and the adjoining land, north of the Bellefourche River, with hardly an exception, contain rather

large quantities of salts. Over the greater part of these lands the proportion ranges from 0.40 to 0.60 per cent for a depth of 6 feet, and a few areas occur where the concentration is from 0.60 to 1 per cent. On the slopes above these lower lands in widely scattered areas the average amount of alkali in the soil is from 0.20 to 0.40 per cent. Aside from the area shown on the map to contain alkali, there are areas, particularly in the southeastern portion of the survey, where the content is rather high along swales, creek banks, and in very small spots. Owing to the small extent of these areas, it is not possible to show them on a map of the scale used in the survey. A few small areas of similar nature occur in the irrigated lands under the Redwater Canal.

The Pierre shale, which underlies the whole area, carries in seams and fissures considerable quantities of salt, particularly gypsum. Almost all the soils found in the area have been derived from this formation, either directly or indirectly, and have received the alkali from the same source. Under the Redwater Canal the small alkali areas have been formed by the movement and accumulation in poorly drained places of irrigation waters from the higher lands, the alkali resulting from the evaporation of the water.

The salts composing the alkali in this area are gypsum, which is almost always present, sodium sulphate, and magnesium sulphate. Chlorides of these bases are very rare, as are the bicarbonates. Qualitative tests of soils and waters in the field have shown that these last two are frequently wanting, and never occur except in small quantities. Carbonates, or black alkali, are absent and will probably not occur in the soils of this area on account of the amount of gypsum in the soil.

Below is given an analysis of an alkali crust, showing the alkali constituents, and the percentage of each salt present.

Chemical analyses of a typical alkali crust.

[Near N. W. cor. sec. 20, T. 9 N., R. 3 E.]

Constituent.	Per cent.	Constituent.	Per cent.
Ions:		Conventional combinations:	
Calcium (Ca)	1.12	Calcium sulphate ($CaSO_4$)	3.80
Magnesium (Mg)	6.79	Magnesium sulphate ($MgSO_4$)	33.65
Sodium (Na)	20.18	Potassium sulphate (K_2SO_4)	.70
Potassium (K)	.31	Sodium sulphate (Na_2SO_4)	57.19
Sulphuric acid (SO_4)	68.58	Sodium bicarbonate ($NaHCO_3$)	1.80
Chlorine (Cl)	1.40	Sodium carbonate (Na_2CO_3)	.56
Bicarbonic acid (HCO_3)	1.30	Sodium chloride (NaCl)	2.30
Carbonic acid (CO_3)	.32		
		Soluble salts	48.30

The tests made show that, as a rule, there is not enough alkali in the upper 18 inches of soil to impair the growth of crops. The quantity of alkali increases with depth to 3 feet, below which the

content is nearly constant. An average of all the borings made places the salt content of the alkali soils as follows: First foot, 0.21 per cent; second foot, 0.39 per cent; third foot, 0.48 per cent; fourth foot, 0.48 per cent; fifth foot, 0.47 per cent; sixth foot, 0.47 per cent, and the average to a depth of 6 feet, 0.42 per cent. From this it will be seen that the quantity of alkali in the upper soil is not dangerous, but that the average amount in the soil is sufficient to be of some concern to the farmer. Under conditions of dry farming this alkali is of no particular danger, since the annual rainfall in this area is not sufficient to soak down into the lower soil and start an upward movement of the salts. With the application of irrigation water, however, there is danger that the distribution of the salts will be changed, with the final result that much of the land will contain an excess of alkali at the surface or within reach of the roots of crops.

Certain methods of handling the soil will, however, tend to keep the alkali in the subsoil beyond the reach of most crops in all areas, except where the conditions of drainage are least favorable. The quantity of water applied should be no more than will furnish the crop with the necessary moisture, and a very thorough cultivation of the soil should be practiced at all times. Thus very little water will reach the subsoil, evaporation from the surface will be largely prevented and the moisture will be held for the use of the crop. In the case of alfalfa and small grains, frequent cultivation of the soil can not be had, but the thickness with which these crops cover the ground will largely prevent the evaporation of the water.

On sloping lands the alkali is less apt to rise to the surface, since the water soaking into the lower soil will more likely come to the surface at lower levels. But for this reason care should be taken not to overirrigate the higher lands, otherwise the lower fields may have to be abandoned because of the increase of alkali.

If the quantity of alkali shall increase to such an extent that the cultivation of the land is no longer profitable, the only satisfactory remedy will be thorough underdrainage in connection with copious flooding. Since the general texture of the soils is heavy, and there is no subsoil drainage, the use of any temporary methods, as flooding or scraping the surface, will be only an expense and waste of labor. The drainage of these heavy soils will be slow and costly, but it is the only means of permanent reclamation. It can not be too strongly impressed upon the farmers that the continued productiveness of these soils can only be secured by the use of small quantities of water and a very thorough cultivation where the crop will permit, and it would be wise to underdrain the fields as soon as practicable as a preventive measure, whether the crops at the time are showing the effects of the alkali accumulations or not.

SUMMARY.

The Bellefourche area is situated in Butte and Meade counties, in the western part of South Dakota. The distinctive features are the winding valley of the Bellefourche River, the narrow valleys of tributary streams, and the high river terraces and rolling foothills forming the local watersheds. The largest stream is the Bellefourche River, which is fed by many tributaries. The regional drainage is good.

Bellefourche, the county seat of Butte County, is the principal town in the area. Other towns are Snoma, Vale, and Minnesela.

Until recent years this portion of the State was mostly an open stock range. The earlier settlers in this area were chiefly interested in the cattle industry, and farming operations were confined to very small fields. Native hay and oats or wheat, and occasionally some corn, were about all the crops grown. In recent years the acreage under cultivation has increased and a wider variety of crops has been grown. These include alfalfa, rye, barley, millet, potatoes, brome grass, vegetables, and some orchard fruits. There is a demand for farm products of all kinds, and the good railroad facilities give connections with outside markets.

The climate of the area, although subject to rather wide ranges in temperature and variations in rainfall, is well adapted to the growing of many different crops, particularly under irrigation. The average annual rainfall is sufficient to make dry farming profitable.

Most of the soils of the area are heavy, compact, and tenacious. The lighter-textured soils are confined mainly to the area south of the Bellefourche River. The surface drainage of the soils, with the exception of one type, is excellent.

The heavier soils are derived from the weathering of the Pierre shale formation or the reworking of this material by water. The lighter soils owe their formation to the action of streams draining the northern portions of the Black Hills.

An abundant supply of water for irrigation is available in the combined flows of the Bellefourche and Redwater rivers. Only a small part of the area is irrigated at the present time, but all of the lands will soon be placed under irrigation by the United States Reclamation Service.

Alkali is generally present in the soils north of the Bellefourche River. Over the larger part of the affected area the quantity in the soil is sufficient to become dangerous to crops when irrigation is practiced. Damage from the rise of alkali can be prevented or delayed by careful use of irrigation water and thorough cultivation, or by underdrainage. Once accumulations have taken place, reclamation

will be a difficult and costly process on account of the impervious nature of the soil and subsoil. Underdrainage and flooding will be necessary.

Gypsum is present to a greater or less extent in nearly all the soils of the area. It is the predominating salt and, with sulphate of sodium and sulphate of magnesium, forms the greater proportion of the alkali. No carbonates or black alkali occur.

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ALKALI MAP

SOUTH DAKOTA
BELLEFOURCHE SHEET

LEGEND

-20 — Less than 20 per cent

20-40 — From 20 per cent to 40 per cent

40-60 — From 40 per cent to 60 per cent

60-1 — From 60 per cent to 1 per cent

Alkali surveyed by
A.T. Strahorn and C.W. Mann
1907

BASE MAP FROM U.S. GEOLOGICAL SURVEY
AND RECLAMATION SERVICE

Scale 1/62500

Contour interval 20 feet.

Field Operations
Bureau of Soils
1907

U.S. DEPT. OF AGRICULTURE
BUREAU OF SOILS
MILTON WHITNEY, CHIEF.

SOIL MAP

SOUTH DAKOTA
BELLEFOURCHE SHEET

SOIL PROFILE
(3 feet deep)

Vale gravelly sandy loam
Sl
Cl

Vale fine sandy loam
Fsl

Vale loam
L
Cl

Pierre clay loam
Cl
C

Pierre clay
C

Orman clay
C

LEGEND
Sl Sandy loam
Cl Clay loam
Fsl Fine sandy loam
L Loam
C Clay

LEGEND

Vg Vale gravelly sandy loam
Vs Vale fine sandy loam
Vl Vale loam
Pl Pierre clay loam
Pc Pierre clay
Oc Orman clay
M Meadow

Soils surveyed by
A.T. Strahorn and C.W. Mann
1907

BASE MAP FROM U.S. GEOLOGICAL SURVEY
AND RECLAMATION SERVICE

Scale 1/250

1 ½ 0 1 2 3 4 Miles

Contour interval 20 feet.

A. Hoen & Co. Lith. Baltimore, Md.

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